Energy Audit Workbook

Institutional Conservation Program

Montana Department of
Natural Resources and Conservation

DNRC

1520 East Sixth Avenue
Helena, MT 59620-2301

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FOREWORD

The Energy Audit Workbook has been prepared by the Energy Division of the Montana Department of Natural Resources and Conservation (DNRC), for use in the Institutional Conservation Program (ICP). This program which was authorized by the National Energy Act of 1978, is designed to encourage energy conservation improvements in buildings owned by schools and hospitals.

The workbook is based on a publication entitled: "Making Sense of Your Energy Dollar," prepared for the U.S. Department of Energy to assist states in preparing their own workbooks for the Institutional Conservation Program. The program is managed in Montana by DNRC, and funded in part by the U.S. Department of Energy (DOE).

While recommendations contained in this workbook have been reviewed for technical accuracy, DNRC and DOE are not liable if potential cost savings identified in this workbook are not actually achieved. Neither of the above agencies endorses or recommends the use of any specific brand of equipment which may be represented in this workbook.

Special thanks to Mark Hines for compiling the material, Jim Bond for the cover photos, Dan Vichorek for editing, Kerry Campbell for completing the word processing, and Ross Campbell for the graphic design and layout.

HOW TO COMPLETE THE ENERGY AUDIT WORKBOOK

The Energy Audit Workbook has been designed for qualified energy auditors to use in assessing potential energy conservation projects in Montana's public buildings.

The workbook includes a step-by-step process for conducting an energy audit and serves as a guide for implementing and monitoring a comprehensive energy management program. The Energy Audit Checklist (Step 2) identifies simple, low-cost or no-cost energy-saving operation and maintenance procedures, called O & Ms. The checklist also includes potential energy conservation measures (ECMs) which would require engineering analysis to determine the energy savings and cost of the project.

The Energy Audit Workbook can be used to determine whether a detailed technical analysis of the building's energy using systems should be completed. This analysis, which is called a Technical Assistance (TA) Report, includes a list of potential ECMs and a summary of the energy savings and estimated costs.

THE INSTITUTIONAL CONSERVATION PROGRAM

Buildings that are potentially eligible for the Institutional Conservation Program (ICP) are public and private nonprofit schools and hospitals built before May 1, 1989. Partial funding for the Technical Assistance Report and ECM retrofit projects are available through the ICP Program.

The Energy Audit Workbook can be completed by anyone from a building operator to a licensed engineer. The more experience the energy auditor has in energy conservation, the more valuable the completed workbook will be in assessing the buildings potential for energy retrofit projects. ONE WORKBOOK SHOULD BE USED FOR EACH BUILDING AUDITED.

A completed energy audit workbook and ICP grant application must be submitted to the ICP Program Manager by Dec. 1 to be eligible for a Technical Assistance (TA) grant. A completed TA Report and a ICP grant application must be submitted by December 1 in order to receive an ECM grant. The submittal date could change in the future so interested parties should contact the ICP Manager for verification.

The ICP Manager will answer any questions concerning the workbook and the program. Please contact::

ICP PROGRAM MANAGER
DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
ENERGY DIVISION
1520 EAST 6TH AVENUE
HELENA, MONTANA 59620
(406) 444-6697

GUIDELINES
FOR COMPLETING THE ENERGY AUDIT WORKBOOK

STEP 1

Complete the Building Energy Consumption Inventory (pages 6-15). This will give a basic rundown of the energy systems in the building, how much fuel, what kind of fuel is used, and what the building's potential is for installation of solar or other renewable energy systems. Instructions are included in this step.

STEP 2

Complete the Energy Audit Checklist (pages 16-39). The items listed in the checklist cover common energy consumption inefficiencies found in eight basic aspects of building operation: Administrative (the operation and use of the building by people), Lighting, Building Envelope, Ventilation, Heating, Cooling, Water Heating and Special. The letters used in the checklist numbering system correlate to the first letters of the eight basic aspects of building operation, such as A-1, L-2, or V-3. The auditor should walk through the building and determine whether each of the checklist conditions exists. Indicate by checking either the "Yes" or "No" box under the "EXISTS" column. Then check either the "Yes" or "No" box under the "RECOMMENDED" column for each listed O & M. Once you have gone through all items in the Energy audit Checklist, complete Step 3.

STEP 3

Complete the Auditor Information Form on page 43.

STEP 4

Send the original and one copy of the Montana Energy Audit Workbook along with the application to the Montana Department of Natural Resources and Conservation, Energy Division. This step is required to verify the building's eligibility for Technical Assistance funding under the Department of Energy's Institutional Conservation Program.

STEP 1: BUILDING ENERGY CONSUMPTION INVENTORY

Section I: Building Identification

1. Building Name _____

2. Institution Name _____

3. Building Address (Street, City, County, Zip) _____
_____

4. Contact Person _____ Phone _____

5. Name of Legal Owner (if different than 2. above) _____
Address of Legal Owner (Street, City County, State, Zip) _____
_____

6. Ownership Category (Circle appropriate code of legal owner)
1 Public 2 Private Non-Profit 3 Indian Tribe

7. Building Type (Circle one only)
1 School 2 Hospital 3 Public Care Institution 4 Local Government

8. Building Function (Circle one only)

SCHOOL
1 Elementary
2 Secondary
3 College or University
4 Vocational
5 Local Educational Agency Administration Building
6 Other (Specify)

HOSPITAL
7 General
8 Tuberculosis
9 Other (Specify)

PUBLIC CARE INSTITUTION
10 Nursing Home
11 Long Term Care-Other than Nursing Home
12 Rehabilitation Facility
13 Public Health Center
14 Residential Child Care Center
15 Other (Specify)

LOCAL GOVERNMENT
16 Office
17 Storage
18 Service
19 Library
20 Police Station
21 Fire Station
22 Other (Specify)

Section II: Major Energy Systems

(Circle the numbers that describe each of the following systems and fuels in the buildings.)

9. PRIMARY HEATING SYSTEMS
1 Hot water or steam supplied from central plant
2 Steam boiler
3 Hot water boiler
4 Heat pump
5 Furnace
6 Unit Heater
7 Other (Specify)

10. HEATING SOURCES
1 Electricity
2 Natural gas
3 Fuel oil #2
4 Fuel oil #6
5 Coal
6 LPG (propane)
7 Solar
8 Other (Specify)

11. DOMESTIC HOT WATER SYSTEMS
(Circle the number that describes how domestic water is heated.)
1 Hot water or steam supplied from central plant
2 Electricity
3 Natural gas
4 Fuel oil #2
5 Fuel oil #6
6 Coal
7 LPG (propane)
8 Solar
9 Other (Specify)

12. COOLING SYSTEMS

0 None
1 Chilled water supplied from central plant
2 Chilled water-centrifugal
3 Chilled water-absorption
4 Refrigeration-water cooled compressor-air cooled
5 Refrigeration-steam turbine comp.
6 Evaporative cooling unit
7 Other (Specify)

13. COOLING SOURCES

0 None
1 Electricity
2 Natural gas
3 Fuel oil #2
4 Fuel oil #6
5 Coal
6 LPG (propane)
7 Solar
8 Other (Specify)

14. TERMINAL SYSTEMS/PERIMETER-STEAM

1 Perimeter-hot water
2 Perimeter-heated air
3 Variable air volume
4 Dual duct
5 Terminal reheat
6 Other (Specify

15. LIGHTING SYSTEMS

1 Fluorescent
2 Incandescent
3 Mercury vapor
4 Metal halide
5 High pressure sodium
6 Low pressure sodium
7 Other (Specify)

16. OTHER ENERGY USING SYSTEMS

(Circle the numbers that describe any other energy using system in the building)
0 None
1 Food service
2 Laundry service
3 Major computer systems
4 Special diagnostic equipment
5 Swimming pool
6 Other (Specify)

17. HEATING SYSTEM LOCATION

(Circle the numbers that best describe the location of the primary heating system)

1 Outside the building
2 Within the building on the ground floor
3 Within the building in the basement
4 On the roof
5 Other (Specify)
(If the heating system is within the building or on the roof, circle the number from the following list which best describes the type of heating system.)
6 Centrally located
7 Multiple units
8 Central and multiple units

18. DOMESTIC HOT WATER HEATING SYSTEMS LOCATION

(Circle the numbers that best describe the location of the domestic hot water systems)

1 Outside the building
2 Within the building on the ground floor
3 Within the building in the basement
4 On the roof
5 Other (Specify)

(If the water heating system is within the building or on the roof, circle the number from the following list which best describes the type of domestic hot water system.)

6 Centrally located
7 Multiple units
8 Central and multiple units

Section III: Building Characteristics

19. GROSS SQUARE FEET (Enter the square footage of all heated or cooled floor areas enclosed in the building. Calculate square footage from the outside building dimensions or from the center line of common walls, if building is attached to other buildings.)

20. NUMBER OF STORIES (Enter the number of stories in this building. Do not count basement, if unoccupied.)

21. LAST MAJOR ADDITION (Enter the year of the last major addition to the building, if any.)

22. YEAR (Enter the year building was first placed in service.)

23. LOCATION (Circle the number which best describes the location of the building.)

1 Urban 2 Suburban 3 Rural

24. FUNCTIONAL USE CHANGES (Circle the numbers from the following list that describe major changes planned in functional use or mode of operation in the next 15 years, if any.)

0 None
1 Demolition
2 Disposal
3 Rehabilitation
4 Conversion (e.g. from office to warehouse) Specify
5 Other (Specify)

25. ANNUAL OPERATING HOURS (Enter the approximate number of hours and days that the building is normally operated.)

Daily hours of operation _____ X days per week _____ = Total hours per week _____

WEEKLY NON-USE OR LIMITED-USE PERIODS
(Enter the number of weekly periods of non-use or limited-use by quarter.)
Jan-Mar _____ Apr-Jun _____ Jul-Sep _____ Oct-Dec _____ Total # Weeks _____

ANNUAL OPERATING HOURS
Calculate the total of annual operating hours as follows:
Total hours per week _____ X _____ total # of weeks of non-use or limited-use) = _____ Annual Operating Hours

26. BUILDING CONDITIONS (Circle the number that best describes general building conditions. Please include a brief explanation.)

1 Excellent
2 Good
3 Fair
4 Poor

Brief Explanation (Please give a overview of the function of the building and the condition of the building structure and HVAC systems.)

_____
_____
_____
_____
_____
_____

Section IV: Building Characteristics Affecting use of Solar Energy

(Circle the number that best describes the following characteristics of the building.)

27. BUILDING SHAPE
1 Square
2 Rectangular
3 E Shaped
4 H Shaped
5 Other

28. ROOF ANGLE
1 Flat roof
2 Pitched roof facing south
3 Pitched roof not facing south
4 Other

29. EXTERIOR MATERIAL OF THE SOUTH FACING WALL
1 Masonry (brick, concrete, stone, stucco)
2 Wood
3 Metal
4 Other (Specify)

30. ROOF TOP STRUCTURES
(Circle the numbers that best describe any roof top structures.)
0 None
1 Chimney
2 Heating or cooling equipment
3 Water tower
4 Stair hatch
5 Mechanical equipment rooms
6 Other permanent structures, Specify: _____

31. APPROXIMATE PERCENTAGE OF GLASS AREA ON WALL THAT MOST NEARLY FACES SOUTH
1 Less than 25%
2 25%-75%
3 Over 75%

32. IS MORE THAN HALF THE BUILDINGS' ROOF AREA OR SOUTHERN WALL SURFACE HEAVILY SHADED BY SHRUBS, TREES, BUILDINGS OR OTHER OBSTRUCTIONS FOR MORE THAN 4 HOURS A DAY?
Circle One: Yes No

33. INDICATE WHETHER OPEN LAND, SUCH AS FIELDS, YARDS AND PARKING AREAS ARE AVAILABLE WITHIN THE IMMEDIATE VICINITY OF THE BUILDING.
Circle One: Yes No

34. PRIMARY STRUCTURAL ROOF COMPONENTS (Circle the numbers from the following list that describe the structural characteristics of the roof of the building.)
1 Steel 2 Wood 3 Concrete 4 Other (Specify)

35. ROOFING MATERIAL (Circle the numbers that describe the materials used to construct the roof of the building.)
1 Shingles 2 Slate or tile 3 Built up materials 4 Metal 5 Other (Specify)

36. SOLAR ENERGY POTENTIAL (The Department of Energy has determined that the following characteristics are significant in determining the potential of a building for using solar energy heating systems. Circle the numbers from the list that describe characteristics of the building.)

1 The roof of the building is flat or pitched and generally south-facing: the roofing materials are durable and easily worked; the structural members have sufficient capacity to support additional weight; and the roof is relatively free of obstructions that would hinder the installation of a solar energy system or cause shading.

2 The wall of the building that generally faces south is over 50% glass and the predominant solid wall construction material is masonry or metal.

3 Less than 50% of the building's roof and south-facing walls are shaded for more than 4 hours per day.

4 The building uses electricity for space heating and domestic hot water, or oil, natural gas, or LPG for space heating and electricity for domestic hot water.

5 The shape of the building is square or rectangular and the distance between a potential solar installation and the primary heating, cooling, or domestic hot water system to which it would be connected is less than 50 feet.

Section V: Energy Conservation Activities

37. ENERGY MONITOR (Has a person been designated to monitor and evaluate energy use in the building.)
1 Yes 2 No
If yes, enter
Name: _____
Position: _____
Phone: _____

38. ENERGY AUDIT INFORMATION (Circle the number that best describes activities which have been undertaken to date to conserve energy in the building, if any.)

1 No activities have been undertaken to date

2 A partial energy audit has been completed (not by an engineer or architect) indicating the building has energy conservation opportunities.

3 A complete energy audit has been completed (not performed by an engineer or architect) indicating the building has energy conservation opportunities.

4 Detailed studies completed by engineers or architects indicate the building has energy conservation opportunities.

5 Detailed studies completed by engineers or architects indicate the building has energy consumption opportunities, including feasibility of renewable resources such as solar.

39. PLEASE LIST MAJOR ENERGY CONSERVATION MEASURES WHICH HAVE BEEN IMPLEMENTED IN THE BUILDING, IF ANY.

MEASURE	COST	ANNUAL ENERGY SAVINGS
Example: Additional roof insulation	$2,400	250 MCF Natural Gas

Section VI: Complex

40. COMPLEX (Indicare whether this building is part of a complex in which hot water, steam, or chilled water is supplied from a central power plant.)

(Circle One) 1 Yes 2 No

If YES, please complete Section VII for this building only. Annual consumption figures should be calculated for the entire complex and then allocated to this building based on the gross square footage of this building compared to total square footage of all buildings served by the central plant.

If NO, continue on to Section VII.

Section VII: Annual Energy Consumption

(Information for this section can be obtained by completing the energy consumption worksheet - see instructions next page.)

ENERGY TYPE	ANNUAL USE	X	CONVERSION FACTOR	=	ANNUAL Btu	ANNUAL COST
1. ELECTRICITY	kWh	X	3,413	=		$
2. NATURAL GAS	MCF	X	950,000	=		$
	Therm	X	100,000	=		$
3. FUEL OIL #2	Gal.	X	138,000	=		$
4. FUEL OIL #6	Gal.	X	146,000	=		$
5. COAL	Tons	X	21,000,000	=		$
6. LPG (PROPANE)	Gal.	X	91,500	=		$
7. PURCHASED STEAM	1000 Lbs.	X	980,000	=		$
8. OTHER (SPECIFY)		X		=		$
			ANNUAL TOTALS			$

Calculate the Energy Use Index

41. Btu per Gross Square Foot (GSF) (Divide total annual Btu by GSF from #19.) _____

Heating Degree Days (for location and same year as utility bill; consult local utility) _____

Btu per GSF per HDD _____

42. COST FOR GSF (Divide total annual cost by GSF from #19.) _____

43. ELECTRICAL DEMAND RATE (Answer only if electric utility bills are based on a demand rate. Entet the highest measured electrical demand and the month for which it was recorded)

Highest measured demand: _____ Measured in month of: _____

ENERGY CONSUMPTION WORKSHEET

MONTH/YEAR	ELECTRICITY			NATURAL GAS		FUEL OIL		OTHER	
	kWh	Demand kW if known	Cost	Therms or MCF	Cost	Gallons	Cost	Units	Cost
TOTALS									

INSTRUCTIONS:

1 Assemble all energy bills - electricity, gas, oil and the like for the most recent 12 month period if possible. If some bills are missing, the billing department of the utilities can provide copies. Many utilities, such as the Montana Power Company, will provide a free computer printout of energy consumption during the previous 12 months.

2 Record the amount of your monthly energy use and cost on the energy consumption worksheet. Your usage will be expressed on the bill in one of the ways listed below. There are two columns for each of the three major fuels listed below, plus a space for other fuels, if needed.

Fuel	Units
Electricity	Kilowatt hours (kWh)
Natural Gas	Therms (100,000 Btu)
Oil	Thousand Cubic Feet (MCF)
Coal	Gallons (Gal.)
LPG (propane)	Tons
Purchased Steam	Pounds (Lbs.)

Use the correct unit to express any fuels listed in the other column.

3 Total both energy use and cost for the reporting period for every fuel type consumed and transfer that information to Section VII. If possible, use fuel conversions obtained from local utility representative for your location.

Section VIII:

(This section attempts to estimate the electrical energy being consumed in the building by lighting, heating, ventilating and air conditioning system, and special systems.)

44. LIGHTING (Select representative areas in the building and calculate the watts per square foot for each. Select at least 4 areas, 5 or 6 if the building has many uses. Using this information and information calculated previously, calculate watts per square foot for the entire building and the annual electrical consumption (kWh) by lighting as follows:)

AREA #1	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles
AREA #2	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles
AREA #3	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles
AREA #4	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles
AREA #5 Optional	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles
AREA #6 Optional	Watts per fixture	X	# of fixtures	=	Total watts	+	Square footage of area	=	Watts/ft²	Ave. Foot Candles

TOTAL WATTS/FT² OF AREA

Total Watts/ft² of area	+	Number of areas	=	Average watts/ft²			

Gross square feet (see 19)	X	Ave. watts/ft²	=	Total watts	+ 1000	=	Total kW

Total kW	X	Annual operating hours (see 25)	=	Annual kWh-lighting

45. SPECIAL SYSTEMS (List all energy consuming equipment in the building other than lighting and equipment that is a part of the HVAC System. Examples: Kitchen equipment, laundry equipment, electric water heaters, diagnostic equipment, treatment equipment, computers, elevators, kilns, etc. For each, calculate annual kWh. The sum of these figures will equal total kWh for special systems in the building. Attach additional sheets if necessary.)

LIST OF SPECIAL EQUIPMENT	kW RATING	X	ANNUAL HOURS OF USE	=	ANNUAL kWh
				TOTAL kWh	

46. HVAC SYSTEM (Calculate the electrical energy being consumed by fans, pumps, compressors, etc. as follows:)

Annual kWh - lighting (see 44)	+	Annual kWh-special systems (see 45)	=	Total kWh-non-HVAC

Annual kWh-total (see Section VII)	-	Total kWh--non-HVAC	=	Annual kWh-lighting

47. PERCENTAGES (Calculate the percentage of total annual kWh represented by lighting, special systems, and the HVAC System as follows:)

1. LIGHTING	Annual kWh-lighting	+	Annual kWh-total	x 100	=	%
2. SPECIAL SYSTEMS	Annual kWh-special systems	+	Annual kWh-total	x 100	=	%
3. HVAC SYSTEM	Annual kWh-HVAC	+	Annual kWh-total	x 100	=	%

Section IX Non-Electrical Energy Consumption of Building Systems

(This section attempts to estimate the energy, other than electrical energy, being consumed in the building for heating and other purposes. Refer to the energy consumption worksheet for consumption data.)

48. BASE LOAD Btu (This term refers to the level of non-electrical energy consumption in the building during periods when the heating or cooling system is not being used. Only heating fuels, and not electrical energy, should be included in this calculation. Use the conversion factors from Section VII.)

1. Total Btu-June	+	Total Btu-July	+	Total Btu-Aug	x 4	=	Base load Btu

ALTERNATIVE (if the building is characterized by A or B below, calculate base load Btu as follows:)

A. The building is not fully occupied during all or most of June, July and August, such as is common with school buildings; or

B. The building uses a steam-driven central air conditioning system.

2. Total Btu-May	x 12	=	Base load Btu

49. NON-ELECTRICAL ENERGY CONSUMPTION FOR HEATING (Only heating fuels, and not electrical energy, should be included in this calculation. Use the conversion factors from Section VII.)

Annual non-electrical Btu	-	Base load Btu	=	Annual heating Btu			

50. PERCENTAGES (Calculate the percentage of annual non-electrical Btu represented by base load Btu and annual heating Btu as follows:)

1. BASE LOAD Btu	Base load Btu	+	Annual non-electrical Btu	x 100	=	%
2. ANNUAL HEATING Btu	Annual heating Btu	+	Annual non-electrical Btu	x 100	=	%

Section X Total Energy Consumption of Building Systems

(This section attempts to estimate the total energy consumed in the building by lighting, special systems, HVAC electrical, base load, and heating.)

51. TOTAL ENERGY CONSUMPTION (Convert energy consumption (kWh) to Btu and determine the total energy consumption of building systems as follows:)

LIGHTING	Annual kWh-lighting (see 44)	x 3,413	Annual Btu-lighting
SPECIAL SYSTEMS	Annual kWh-Special systems (see 45)	x 3,413	Annual Btu-special systems
HVAC ELECTRICAL	Annual kWh-HVAC systems (see 46)	x 3,413	Annual Btu-HVAC electrical
BASE LOAD			Annual base load Btu (see 48)
HEATING			Annual heating Btu (see 49)
		TOTAL ENERGY (Btu)	

52. PERCENTAGES (Calculate the percentage of total energy represented by the annual Btu consumption for lighting, special systems, HVAC electrical, base load and heating as follows:)

1. LIGHTING	Annual Btu-lighting	+	Total energy (Btu)	x 100	=	%
2. SPECIAL SYSTEMS	Annual Btu-special systems	+	Total energy (Btu)	x 100	=	%
3. HVAC ELECTRICAL	Annual Btu-HVAC electrical	+	Total energy (Btu)	x 100	=	%
4. BASE LOAD	Annual base load Btu	+	Total energy (Btu)	x 100	=	%
5. HEATING	Annual heating Btu	+	Total energy (Btu)	x 100	=	%

STEP 2: ENERGY AUDIT CHECKLIST

The Energy Audit Checklist provided on the following pages requires a walk-through on-site inspection of the building to identify conditions that waste energy, and to indicate how energy can be saved through operating and maintenance procedures and possible energy conservation retrofits.

All O & Ms provided on the checklist must be implemented to qualify for Technical Assistance funding under the Department of Energy's Institutional Conservation Program. Suggested ECMs should not be completed until a thorough analysis is completed by a licensed engineer. Funding for a retrofit cannot be given under the ICP program until a technical assistance report is completed, and then only if the proposed retrofit has a payback period of less than 10 years.

Throughout Step 2, some O & Ms are preceded by a *, indicating that the O & M implementation may require special training for maintenance or operating personnel, or may create other overriding circumstances that make implementation impractical.

ADMINISTRATIVE SYSTEM	EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
A-1. Thermostats on heating/cooling units are accessible to occupant adjustment.	☐	☐		
Suggested O & Ms:				
• Reset thermostats to correct settings.			☐	☐
• Install or replace locking screws to prevent tampering.			☐	☐
Suggested ECMs:				
• Install tamper-proof locking covers on thermostats.			☐	☐
• Install pre-set solid state electric thermostats if existing controls are electric.			☐	☐
A-2. Thermostat settings have not been adjusted for change in seasons.	☐	☐		
Suggested O & Ms:				
• Adjust thermostats to 72° F in heating season and to 75° F during cooling season.			☐	☐
* • Move thermostats from areas subject to extreme temperature fluctuations, such as next to windows, or over a heating or cooling unit.			☐	☐
Suggested ECMs:				
• Replace existing thermostat with one that has separate settings, for cooling and heating, or use one thermostat to control heating and another thermostat to control cooling.			☐	☐
• Consider installation of deadband thermostats so that no heating or cooling takes place between given setpoints, e.g. 68°F to 78°F.			☐	☐
A-3. Unoccupied or little used areas are heated or cooled unnecessarily.	☐	☐		
Suggested O & Ms:				
• Reduce winter thermostat settings to 55° F in unoccupied areas.			☐	☐
* • Where possible, turn off heating systems if nothing in space can freeze, while maintaining existing mechanical ventilation air quantities.			☐	☐
• Use spot heaters/coolers in large spaces with low occupancy.			☐	☐
• Turn off cooling systems in unoccupied areas, if possible, while maintaining existing mechanical ventilation air quantities.			☐	☐
* • In occupied areas, disconnect electrical devices, close drapes, and shut off air systems, if nothing in space can freeze or otherwise be damaged, while maintaining existing mechanical ventilation air quantities.			☐	☐
Suggested ECMs:				
• Install system controls to reduce heating/cooling of unoccupied spaces.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
A-4.	**Off-hour activities are scheduled.**	☐	☐		
	Suggested O & Ms:				
	• Reschedule off-hour activities to accommodate partial shutdown of building systems.			☐	☐
	• Reschedule custodial and cleaning activities during working hours whenever possible.			☐	☐
	• Re-examine original assumptions regarding occupancy patterns and building usage. Modify patterns increased energy efficiency.			☐	☐
	Suggested ECMs:				
*	• Install an automated energy management system that will control all spaces in accordance with usage.				
A-5.	**Building temperatures are not adjusted for unoccupied periods.**	☐	☐		
	Suggested O & Ms:				
	• Reduce thermostat settings by a minimum of 10° F at night, weekends and holidays during the heating season.			☐	☐
	• Shut down all air conditioning units at night and on weekends and holidays when building is unoccupied.			☐	☐
	Suggested ECMs:				
*	• Install automatic controls such as time clocks or automated management systems.			☐	☐
A-6.	**Heating/cooling equipment is operating in lobbies, corridors, vestibules and other public areas.**	☐	☐		
	Suggested O & Ms:				
*	• Close supply ducts and radiators and lower heating set points in the above areas if there is no possibility of freeze-up. Disconnect electrical heating units or switch off at breaker box.			☐	☐
	• Close air conditioning supply ducts serving the above areas.			☐	☐
	Suggested ECMs:				
	• Properly adjust and balance air/water systems and controls.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
A-7.	**Heating/cooling equipment is started before occupants arrive or is operating during last hour of occupancy.**	☐	☐		
	Suggested O & Ms:				
	• Experiment with start-up times and duration of operation to determine satisfactory comfort levels for occupants.			☐	☐
	• Reduce or turn off heating and cooling during the last hour of occupancy, allowing the building to "coast."			☐	☐
	Suggested ECMs:				
*	• Install a time clock or an automated energy management system that will reduce heating or turn off air conditioner.			☐	☐
A-8.	**Air filters and heating/cooling coils do not receive scheduled maintenance.**	☐	☐		
	Suggested O & Ms.				
	• Develop maintenance checklist.			☐	☐
	• Install filter pressure drop gauges.			☐	☐
A-9.	**Equipment associated with laundry and custodial services is used during heavy electrical demand periods.**	☐	☐		
	Suggested O & Ms:				
	• Require that major electrical equipment be used in accordance with guidelines that avoid peak electrical demand periods.			☐	☐
	Suggested ECMs:				
*	• Install a demand control system to automatically monitor power demand and shut off secondary loads in order to lower demand peaks to a pre-established level.			☐	☐
A-10.	**Blinds and curtains are not used to help insulate the building.**	☐	☐		
	Suggested O & Ms:				
	• Instruct personnel to close interior shading devices to reduce night heat loss in winter and to reduce solar heat gain during the summer.			☐	☐
	• Place reminders where appropriate.			☐	☐
	• Repair or replace damaged or missing shading devices.			☐	☐
	Suggested ECMs:				
	• Add reflective or heat absorbing films to reduce solar heat gain in summer. (Caution: natural lighting and solar heat gain in winter will be reduced. Also, unless protected by an additional layer of glass, these films are subject to damage.)			☐	☐
	• Install outdoor shading devices.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
A-11.	**No maintenance records are available of for motors and motor driven equipment.**	☐	☐		
	Suggested O & Ms:				
	• Using nameplate data, prepare an up-to-date list of all motors and pumps used in the facility and list routine maintenance to be performed on each. Check regularly for:				
	1. Correct motor voltage and amperage.			☐	☐
	2. Loose connections and worn contacts.			☐	☐
	3. Unbalanced voltages on 3-phase motors.			☐	☐
	4. Improper grounding.			☐	☐
	5. Packing wear.			☐	☐
	6. Wear and binding on bearings and drive belts.			☐	☐
	7. Proper sequencing of pumps and motors.			☐	☐
	8. Belt slippage			☐	☐
	Suggested ECMs:				
	• Replace worn equipment with more efficient units.			☐	☐
A-12.	**Control devices are not inspected on a regular basis.**	☐	☐		
	Suggested O & Ms:				
	• Routinely check all time clocks and other control equipment for proper operation; correct time and day; and proper programming of on-off set points. Protect from unauthorized adjustment.			☐	☐
	• Mark all multiple switches with identification of the equipment controlled.			☐	☐
	Suggested ECMs:				
*	• Consider installing an automated energy management system.			☐	☐
A-13.	**Conditioned air or heated water is discarded.**	☐	☐		
	Suggested O & Ms:				
	• None practical.				
	Suggested ECMs:				
	• Consider installing a heat recovery device. Install such equipment only after analyzing the energy characteristics of the building, performance of the hardware, and how it fits into the overall energy plan.			☐	☐

	EXISTS		RECOM	
	YES	NO	YES	NO

LIGHTING SYSTEM

L-1. Incandescent lamps are used in offices, workrooms, hallways, gymnasiums, or other frequently used spaces. (Ignore storage closets and other spaces where usage is minimal.) ☐ ☐

Suggested O & Ms:

- Where possible, use a single incandescent lamp of higher wattage rather than two or more smaller lamps of a higher combined wattage. ☐ ☐
- Discontinue using multi-level lamps. The efficiency of single wattage lamps is higher than multi-level lamps. ☐ ☐

Suggested ECMs:

- Use decorative lights minimally. Keep them dimmed if controlled by a dimming switch. ☐ ☐
- Replace non-decorative incandescent lamps with more energy conserving types such as fluorescent (compact fluorescent screw-in lamps or standard fluorescent systems) in office and corridor areas, and metal halide or high pressure sodium systems in large areas such as gymnasiums or garages. ☐ ☐
- Replace conventional floodlights in canister fixtures with elliptical reflector lamps or compact fluorescent lamps (with a reflector and lens if necessary). ☐ ☐

L-2. In fixtures where fluorescent lamps have been removed, the ballasts have not been disconnected. ☐ ☐

Suggested O & Ms:

* • Disconnect ballasts, which still use significant amounts of energy even though tubes have been removed. ☐ ☐

Suggested ECMs:

- Replace unnecessary tubes with "dummy" types which draw little current and yet provide uniform lighting effect. ☐ ☐

		EXISTS		RECOM	
		YES	NO	YES	NO
L-3.	When burned out fluorescent lamps or ballasts have been replaced, more efficient lights have not been installed.	☐	☐		
	Suggested O & Ms:				
*	• When relamping, replace fluorescent tubes with more efficient and lower wattage types such as 34-watt instead of 40-watt to reduce electrical energy consumption.			☐	☐
	• Wherever possible, replace burned out ballasts with more efficient lower wattage energy conserving ballasts.			☐	☐
*	• Consider not replacing burned out bulbs or lamps where delamping is possible, and disconnect ballasts.			☐	☐
	Suggested ECMs:				
	• Install more efficient fluorescent tubes and ballasts in all existing fixtures. (First verify that new lamps will work with existing ballasts.)			☐	☐
	• Lower fixtures to increase illumination on the task area, which may permit a reduction in the number of fixtures or the wattage of lamps.			☐	☐
L-4.	Lamps and fixtures are not clean.	☐	☐		
	Suggested O & Ms:				
	• Establish a regular inspection and cleaning schedule for lamps and fixtures.			☐	☐
	• Replace lens shielding that has turned yellow or hazy with new acrylic lenses that do not discolor.			☐	☐
	Suggested ECMs:				
	• Replace outdated or damaged fixtures with modern types that are easy to clean.			☐	☐
L-5.	Exterior lighting is used.	☐	☐		
	Suggested O & Ms:				
*	• Replace exterior 150-watt flood lamps with 75-watt flood lamps to reduce consumption while maintaining adequate illumination.			☐	☐
*	• Eliminate outdoor lighting where practical.			☐	☐
	Suggested ECMs:				
	• Install a control device (i.e., time clock, photocell) to automatically turn off lights when not needed.			☐	☐
	• Replace exterior incandescent lamps with more efficient types such as high pressure sodium or metal halide.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
L-6.	**Lights are on in unoccupied areas.**	☐	☐		
	Suggested O & Ms:				
	• Provide signs instructing occupants to turn off lights when leaving room.			☐	☐
	• Organize task areas to eliminate unnecessary illumination.			☐	☐
	• Make sure wall switch timers function properly.			☐	☐
	• Identify areas being controlled by banked switches.			☐	☐
	Suggested ECMs:				
	• Rewire switches so a single switch does not control all fixtures in multiple work spaces.			☐	☐
	• Provide timer switches in remote or seldom used areas where occupancy will be brief.			☐	☐
L-7.	**Natural lighting is not optimized.**	☐	☐		
	Suggested O & Ms:				
	• Use natural lighting whenever possible.			☐	☐
	• Clean walls or repaint with light reflective non-glossy colors.			☐	☐
	• Locate work stations requiring high illumination adjacent to windows.			☐	☐
	• Clean windows and skylights.			☐	☐
	Suggested ECMs:				
	• Install light sensors and dimming equipment that automatically compensate for varying natural lighting conditions.			☐	☐
L-8.	**Two lamps have not been removed from four-lamp fixtures, where possible.**	☐	☐		
	Suggested O & Ms:				
*	• Remove two lamps and disconnect ballasts.			☐	☐
L-9.	**Security lighting is not automatically controlled or lighting levels are excessive.**	☐	☐		
	Suggested O & Ms:				
	• When lamps burn out, replace with lower wattage lamps.			☐	☐
	• Establish manual operation schedule that accommodates seasonal change in daylight.			☐	☐
	• Control lighting with existing photo-electric or time clock controls if practical.			☐	☐

	EXISTS		RECOM	
	YES	NO	YES	NO
L-10. Deep baffled downlighting fixtures have conventional "R" reflector lamps installed.	☐	☐		
Suggested O & Ms:				
• When "R" lamps burn out, replace with reflector "ER" lamps which yield approximately the same average light level for half the energy cost.			☐	☐
Suggested ECMs:				
• Replace lamps with compact fluorescent screw-in lamps.			☐	☐
L-11. Light levels are greater than required (e.g., corridors need one-third to one-half the amount of light that office spaces require).	☐	☐		
Suggested O & Ms:				
• Delamp and deballast where possible.				
• Where delamping fluorescent fixtures is not appropriate, consider installing dummy tubes that draw less current, or installing reflectors to increase the efficiency of the fixture.			☐	☐

BUILDING ENVELOPE SYSTEM

B-1. Improper alignment and operation of windows and doors allows excessive infiltration.	☐	☐		
Suggested O & Ms:				
• Realign or re-hang windows or doors that do not close properly. In extreme cases, consider sealing windows permanently.			☐	☐
• Make sure automatic door closing mechanisms work properly and adjust them for faster return.			☐	☐
• Replace or repair faulty gaskets on overhead doors.			☐	☐
Suggested ECMs:				
• Consider installing smaller exterior doors (i.e., delivery doors), to reduce excessive infiltration.			☐	☐
• Install self-closing doors on openings to unconditioned spaces.			☐	☐
• Install a switch on overhead doors to prevent activation of heating/cooling units when doors are open.			☐	☐
• Install vestibule doors at major entrances.			☐	☐
• Install loading dock door seals.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
B-2.	**Ceiling/roof insulation is inadequate or has been water damaged.**	☐	☐		
	Suggested O & Ms:				
	• Repair roof leaks and replace water damaged insulation where required.			☐	☐
	• Verify that vapor barrier faces the conditioned space and is intact.			☐	☐
	Suggested ECMs:				
	• Add new insulation to meet recommended standard. Check the cost effectiveness of this measure, particularly if your facility is over three stories.			☐	☐
B-3.	**Weatherstripping and caulking around all windows, doors, conduits, piping, exterior joints, or other areas of infiltration is worn, broken or missing.**	☐	☐		
	Suggested O & Ms:				
	• Use quality weatherstripping and caulking to ensure that all areas of infiltration are sealed.			☐	☐
	• Replace broken or cracked windows.			☐	☐
	Suggested ECMs:				
	• Where practical, cover all window and through-the-wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.			☐	☐
	• In areas with constant strong winds, consider installing wind screens to protect exterior doors from direct blast of prevailing winds. Screens can be opaque, constructed inexpensively from concrete block, or can be transparent, constructed of metal framing with armored glass. Careful positioning is necessary for infiltration control.			☐	☐
B-4.	**Excessive expanses of glass exist on exterior walls.**	☐	☐		
	Suggested O & Ms:				
	• Keep curtains closed during unoccupied periods.			☐	☐
	• When replacing windows, replace with low-E windows.			☐	☐
	Suggested ECMs:				
	• Consider covering part of the window, leaving enough window to meet ventilation requirement.			☐	☐
	• Install double pane windows.			☐	☐
	• Consider adding reflective or heat absorbing film to minimize solar gain in summer and heat loss in winter. (Any window film reduces natural lighting and winter solar gain.)			☐	☐
	• Consider installation of adjustable outdoor shading devices.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
B-5.	There is no insulation between conditioned and unconditioned spaces.	☐	☐		
	Suggested O & Ms:				
	• Replace damaged insulation.			☐	☐
	Suggested ECMs:				
	• Insulate between heated/cooled spaces and unconditioned or outside areas such as parking garages, storage areas, basement and attics.			☐	☐
	VENTILATION SYSTEM				
V-1.	Too much outdoor air is used to ventilate the building.	☐	☐		
	Suggested O & Ms:				
*	• Adjust outdoor air dampers during hours of occupancy to reduce ventilation with outdoor air to the minimum allowed by codes.			☐	☐
	Suggested ECMs:				
	• Replace old style dampers with new, high quality, opposed-blade models with better close-off ratings.			☐	☐
V-2.	Outdoor air intake dampers are open when the building is unoccupied.	☐	☐		
	Suggested O & Ms:				
	• Close outdoor air dampers when building is unoccupied. Be sure dampers have proper seals and adjust to ensure complete closure.			☐	☐
*	• Where codes permit, close outdoor air dampers during first and last hours of occupancy to permit fast warm-up or cool-down.			☐	☐
	Suggested ECMs:				
*	• Install controls that will automatically close dampers during unoccupied periods.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
V-3.	**Ventilation systems are not used for natural cooling capability.**	☐	☐		
	Suggested O & Ms:				
*	• Whenever possible, use outside air for cooling rather than using refrigeration. (Use economizer cycle, if available.)			☐	☐
	Suggested ECMs:				
*	• Install an economizer cycle to optimize use of outside air for cooling.			☐	☐
V-4.	**Exhaust system operation is not programmed.**	☐	☐		
	Suggested O & Ms:				
	• Discontinue use of unnecessary exhaust fans.			☐	☐
*	• Re-wire toilet exhaust fans to operate only when lights are on. (Fans are often wired in reverse. Correct as needed.)			☐	☐
	• Arrange schedules so exhaust fans run only when needed.			☐	☐
	Suggested ECMs:				
	• Install time clocks or other controls to shut exhaust systems off when not needed (as permitted by code).			☐	☐
	• Install a rheostat in series with exhaust fan so fan speed can control amount of air exhausted.			☐	☐
	• Install activated carbon filter or electrostatic air cleaner to reduce the need for using outside air for ventilation.			☐	☐
	• Install controlled or gravity dampers on all exhaust ducts to close ducts when fan is not operating.			☐	☐
V-5.	**Return air, outdoor air and exhaust dampers are not sequencing properly.**	☐	☐		
	Suggested O & Ms:				
	• Adjust damper linkage.			☐	☐
	• Be sure damper motors are operating properly.			☐	☐
	• Readjust position indicators to accurately indicate damper positions.			☐	☐
	• Reset linkage, repair or replace dampers if blades do not close tightly.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
V-6.	**Air filters and heating/cooling coils do not receive scheduled maintenance.**	☐	☐		
	Suggested O & Ms:				
	• Develop maintenance schedule.			☐	☐
	• Install filter pressure drop gauges.			☐	☐
	• Close all outdoor air intake dampers when equipment is shut off and building is unoccupied.			☐	☐
	Suggested ECMs:				
	• Replace old style dampers with new, high quality, opposed-blade models with better close-off ratings.			☐	☐

HEATING SYSTEM

H-1.	**Multiple boilers or heaters fire simultaneously.**	☐	☐		
	Suggested O & Ms:				
*	• Adjust controls so boiler #2, for example, will not fire until boiler #1 no longer satisfies demand.			☐	☐
	Suggested ECMs:				
	• Purchase and install automatic staging controls if applicable.			☐	☐
H-2.	**Stack temperature appears too high (greater than 400 °F plus room temperature). (Stack temperature should be measured within one foot of the point where stack joins heater or boiler, and before the point where dilution air (if any) is introduced into the stack.)**	☐	☐		
	Suggested O & Ms:				
*	• Ensure that a proper amount of air for combustion is available in furnace room.			☐	☐
	• Examine and clean air intake filters.			☐	☐
*	• Perform flue gas analysis on a regular basis to ensure proper air to fuel ratio.			☐	☐
*	• If furnace is over-firing, verify that spuds and nozzles are properly sized. Also make sure that fuel pressures are not too high.			☐	☐
	• Prepare testing schedule and log for test results.			☐	☐

NOTE: Checks and maintenance of boiler operations should be performed by qualified personnel. If there are none on the staff of the institution, consider hiring a service contractor.

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
H-3.	**Water in heating system is heated when there is no need.**	☐	☐		
	Suggested O & Ms:				
*	• Turn off boiler, pumps or heat source when not needed.			☐	☐
	Suggested ECMs:				
	• Install control to automatically shut down heat generating device when outside air temperature reaches 60°F.			☐	☐
H-4.	**Space temperatures are higher or lower than thermostat settings.**	☐	☐		
	Suggested O & Ms:				
*	• Recalibrate thermostat.			☐	☐
*	• Blow out moisture, oil and dirt from pneumatic lines in pneumatic systems. Clean contacts in electrical control systems.			☐	☐
*	• Recalibrate controllers.			☐	☐
*	• Ensure that control valves and dampers are modulated properly.			☐	☐
*	• Ensure that heat generating device is producing heat and heat distribution to the space is unobstructed.			☐	☐
*	• Make sure air intake volume is not excessive.			☐	☐
	Suggested ECMs:				
	• For electrical control systems, install pre-set solid state thermostats which do not require calibration.			☐	☐
H-5.	**Heating system hot water is too hot during periods of mild weather.**	☐	☐		
	Suggested O & Ms:				
*	• Experiment with hot water temperature reduction until an acceptable comfort level is reached.			☐	☐
*	• Make sure reset controls work properly.			☐	☐
	Suggested ECMs:				
	• Purchase and install automatic temperature controls to schedule heating water according to outside temperature.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
H-6.	**Condensate from purchased steam is being discharged to sewer drain.**	☐	☐		
	Suggested O & Ms:				
	• None practical.				
	Suggested ECMs:				
	• Install pump to return condensate to boiler or to return condensate by gravity if possible. Condensate also can be used to heat domestic water or boiler combustion air prior to its return to the boiler feedwater system.			☐	☐
H-7.	**Heating pilot lights are on during cooling season.**	☐	☐		
	Suggested O & Ms:				
	• Turn pilots off. (Enter shut-off and turn-on dates in your log book and post a notice in the boiler/furnace room.)			☐	☐
	Suggested ECMs:				
	• Replace standing pilots with new electronic ignition models to avoid unnecessary fuel consumption.			☐	☐
H-8.	**Steam, condensate and heating water piping insulation is in disrepair or missing.**	☐	☐		
	Suggested O & Ms:				
	• Inspect pipes for damaged or missing insulation. Repair or replace as needed.			☐	☐
	Suggested ECMs:				
	• Install additional pipe insulation in accordance with design specifications and energy conservation codes.			☐	☐
H-9.	**Operation of oil burner produces too much smoke and soot.**	☐	☐		
	Suggested O & Ms:				
*	• Inspect burner nozzles for wear, dirt and incorrect spray angles. Clean and adjust as necessary.			☐	☐
*	• Verify that oil is flowing freely and oil pressure is correct.			☐	☐
*	• Perform flue gas analysis to set proper air to fuel ratio.			☐	☐
	Suggested ECMs:				
	• Purchase kit for flue gas analysis if frequent testing is anticipated.			☐	☐

	EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
H-10. Burner short-cycles.	☐	☐		
Suggested O & Ms:				
• Hot water temperature limit switch may be set too low. Reset as required.			☐	☐
• Thermostat may be faulty. Replace if necessary.			☐	☐
H-11. Steam radiators or other steam equipment are not in proper operating condition.	☐	☐		
Suggested O & Ms:				
• Check the temperature of the pipe on the downstream side of steam traps. If it is too hot, the trap is probably passing steam. This can be caused by dirt in the trap, a valve off the stem, excessive steam pressure, or worn trap parts (especially valves and seats). If the pipe is moderately hot (as hot as the hot water pipe), it probably is passing condensate, which it should do. If it's cold, the trap is not working at all, and should be replaced or repaired. Initiate a steam trap maintenance program.			☐	☐
• Clean or replace thermostatic control valves on radiators.			☐	☐
• Check air vent valve. If not operating properly, replace.			☐	☐
* • If thermostatic steam trap is malfunctioning, clean or replace bellows element.			☐	☐
* • Water pockets may be obstructing steam flow. Correct by repitching or re-routing pipes.			☐	☐
Suggested ECMs:				
• Replace worn out steam traps with modern traps, which are more reliable and easier to maintain.			☐	☐
• Install thermostatic control valves on radiators.			☐	☐
H-12. Radiators, convectors, baseboards or finned-tube heaters are not providing sufficient heat.	☐	☐		
Suggested O & Ms:				
• Boiler temperature may have dropped. Correct as necessary.			☐	☐
• Bleed air from units.			☐	☐
• Establish a systematic cleaning schedule.			☐	☐
• Remove items obstructing discharge grilles.			☐	☐
• Bleed off water in pneumatic air lines if necessary. (Pneumatic lines may be frozen or leaking air.)			☐	☐
• Repair faulty valves.			☐	☐
• Repair or replace faulty thermostats.			☐	☐
• Hot water pump or booster pump may not be functioning. Repair or replace as necessary.			☐	☐
• Clean radiators (convectors, baseboards, and finned-tube heaters).			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
H-13.	**Boiler is not maintained and inspected regularly to ensure optimum efficiency.**	☐	☐		
	Suggested O & Ms:				
	• Remove scale deposits, accumulation of sediment and boiler compounds on water surfaces. Examine and treat rear portion of boiler (the area most susceptible to scale formation).			☐	☐
	• Remove soot from tubes.			☐	☐
	• Observe the fire when the unit shuts down. If the fire does not cut off immediately, it could indicate a faulty solenoid valve. Repair and seal as necessary.			☐	☐
*	• Perform flue gas analysis to determine combustion efficiency.			☐	☐
	Suggested ECMs:				
	• Replace dangerous or ineffective units with more efficient modular type units. Implement all O & Ms and retrofits that reduce the heating load prior to choosing a new furnace or boiler. This will help ensure that the new unit is not oversized.			☐	☐
	• If you have a fire-tube boiler, install fire-tube baffles to improve efficiency.			☐	☐
H-14.	**Combustion air to boiler furnace is not preheated.**	☐	☐		
	Suggested O & Ms:				
	• None practical.				
	Suggested ECMs:				
	• Use heat from flue gas to preheat combustion air by means of a heat recovery device.			☐	☐
	COOLING SYSTEM				
C-1.	**Space temperature is higher or lower than thermostat setting.**	☐	☐		
	Suggested O & Ms:				
*	• Recalibrate space thermostat.			☐	☐
*	• Blow out moisture, oil and dirt from pneumatic lines on pneumatic control system. Clean contacts on electric control system.			☐	☐
*	• Recalibrate controllers.			☐	☐
*	• Verify that control valves and dampers modulate properly, especially the economizer section of the system.			☐	☐
*	• Limit excessive outdoor air intake when not operating economizer cycle.			☐	☐
	Suggested ECMs:				
	• For electric control systems, install pre-set, solid state thermostats that do not require calibration.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
C-2.	**Chiller is operating during cool or cold weather to provide air conditioning.**	☐	☐		
	Suggested O & Ms:				
	• During cold weather, reduce chiller operating hours by starting chiller later in the day. It may be possible to shut down the chiller on the coldest days.			☐	☐
*	• During cold weather, experiment with raising the chilled water temperature.			☐	☐
	• If HVAC system is equipped with an economizer cycle, confirm that equipment and controls are operating properly.			☐	☐
	Suggested ECMs:				
	• Provide a water interchange system injecting cooling tower condenser water directly into the system's chilled water circuits. Except for pumping and cooling tower fan horsepower, this provides "free" cooling. Special care must be taken in treating and filtering condenser water.			☐	☐
	• If system is forced air, using direct expansion (DX) coils and air cooled condenser, install economizer cycle to obtain free cooling.			☐	☐
	• In dry climates, investigate the possibility of replacing some or all of the mechanical cooling with evaporative cooling (swamp coolers).			☐	☐
C-3.	**Reheat coils are used to maintain zone temperatures.**	☐	☐		
	Suggested O & Ms:				
*	• Lower hot water temperature.			☐	☐
*	• Raise chilled water temperature. This will raise the temperature of air supplied to space.			☐	☐
	• During summer months, turn hot water flow off by shutting valve at reheat coil or by turning off hot water circulating pump.			☐	☐
	Suggested ECMs:				
	• Convert to variable air volume (VAV) system if the reheat coils are not necessary during the heating season.			☐	☐
C-4.	**Multiple air conditioning compressors start at the same time.**	☐	☐		
	Suggested O & Ms:				
*	• Adjust electric controls to stage compressor operation properly.			☐	☐
	Suggested ECMs:				
	• Purchase and install automatic controls if they do not exist. This will allow compressor #2, for example, to cut in when compressor #1 can no longer satisfy air conditioning load.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
C-5.	**Building uses a dual duct or multizone system.**	☐	☐		
	Suggested O & Ms:				
*	• Lower hot deck temperature.			☐	☐
*	• Raise cold deck temperature.			☐	☐
*	• During summer months, turn heating source off.			☐	☐
*	• If unit has an economizer cycle, turn mechanical cooling off in winter.			☐	☐
	Suggested ECMs:				
	• Convert dual duct or multizone systems to variable air volume (VAV), if building has a separate heating system.			☐	☐
*	• Install controls to automatically reset hot and cold deck temperatures.			☐	☐
C-6.	**Insulation on cooling line pipes and ducts appears inadequate or is missing.**	☐	☐		
	Suggested O & Ms:				
*	• Repair or replace damaged insulation.			☐	☐
	Suggested ECMs:				
*	• Insulate all delivery lines and ducts in accordance with recommended R-values.			☐	☐
C-7.	**Air conditioning load trips circuit breaker on hot days.**	☐	☐		
	Suggested O & Ms:				
*	• Tighten wire lugs if loose.			☐	☐
*	• Replace defective circuit breakers.			☐	☐
	• Clean condensers on air cooled systems.			☐	☐
*	• Clean scale build-up in condensers on water cooled systems.			☐	☐
	Suggested ECMs:				
	• Consider installing insulated underground storage tank that would allow night operation of chiller when electrical demand is low. This reservoir tank would be a source of supply of chilled water for daytime operation. Chiller would not be operated during the day.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
C-8.	**Air of inadequate volume or temperature is being discharged through grilles, and the space temperature cannot be maintained.**	☐	☐		
	Suggested O & Ms:				
*	• Defrost evaporator coil if iced. Determine cause of icing and correct.			☐	☐
	• Clean evaporator coil, fins and tubes.			☐	☐
	• Clean or replace air filters.			☐	☐
	• Fire damper may be closed. Open and replace fusible link if necessary.			☐	☐
	• Balancing damper may have slipped and closed. Open to correct position and tighten wing nut.			☐	☐
*	• If fan is rotating backwards, reverse rotation by reversing electrical contacts.			☐	☐
	• Clean condenser coil and water tower nozzles.			☐	☐
	Suggested ECMs:				
	• Install differential pressure-sensing switches to trip alarm when air flow drops significantly.			☐	☐
C-9.	**Refrigeration condensers or coils are dirty, clogged and not functioning efficiently, and not allowing proper air flow.**	☐	☐		
	Suggested O & Ms:				
	• Determine if normal operating temperatures and pressures have been identified and if all gauges are checked frequently to ensure that design conditions are being met.			☐	☐
*	• Increased system pressure may be due to dirty condensers which decrease system efficiency. High discharge temperatures often are caused by defective or broken compressor valves. Repair or adjust as required.			☐	☐
*	• Inspect the liquid line leaving the strainer. If it feels cooler than the liquid line entering the strainer, it is clogged. It is very clogged if frost or sweat is visible at the strainer outlet. Clean as required.			☐	☐
•	• Clean coils and other elements as needed on a scheduled basis. Include dehumidification coils.			☐	☐
C-10.	**Chilled water piping, valves and fittings are leaking.**	☐	☐		
	Suggested O & Ms:				
*	• Repair joint or piping leaks.			☐	☐
*	• Repair or replace valves.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
C-11.	**Refrigeration compressors run continually on direct expansion systems.**	☐	☐		
	Suggested O & Ms.				
*	• Contacts in starter circuits of controls may be fused. Repair and replace as necessary.			☐	☐
*	• Bubbles in sight glass indicate low refrigerant charge. Repair leaks and recharge.			☐	☐
*	• Refrigerant charge may be too high. Check discharge pressure and purge excess.			☐	☐
*	• Compressor valves may be leaking. Overhaul compressor.			☐	☐
*	• Liquid line solenoid valve may be stuck open. Repair or replace.			☐	☐
	Suggested ECMs:				
	• Load may be greater than design. Consider replacing with chiller and water cooled condenser system.			☐	☐
C-12.	**Multiple parallel chillers have no isolation schedule for extended light-load operation.**	☐	☐		
	Suggested O & Ms:				
	• Create load vs. capacity matrix.			☐	☐
	• Isolate unneeded chillers.			☐	☐
C-13.	**Chiller evaporating and condensing temperatures are not optimized.**	☐	☐		
	Suggested O & Ms:				
	• Increase chiller evaporator temperature and decrease chiller condensing temperature following manufacturer's recommendations.			☐	☐
C-14.	**Evaporator temperature is lower than required for produce or process.**	☐	☐		
	Suggested O & Ms:				
	• Increase temperature set-point.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
C-15.	Refrigeration compressor short-cycles.	☐	☐		
	Suggested O & Ms:				
*	• Refrigerant charge is low or refrigerant is leaking. Find and repair leak. Recharge system.			☐	☐
*	• Repair electrical control circuit if required.			☐	☐
*	• Reset high/low pressure control differential settings if needed.			☐	☐
*	• Liquid line solenoid valve may be leaking. Repair or replace.			☐	☐
	• Evaporative coil may be dirty. Defrost and clean.			☐	☐
	• If frost is detected on the liquid line strainer, it is clogged. Clean.			☐	☐
	• Clean condenser coil.			☐	☐
	• If condenser is a cooling tower, make sure that spray nozzles are not plugged. Clean to make sure water flow is unobstructed.			☐	☐
	• Remove scale deposits from shell or tubes on water condensers.			☐	☐
*	• Repair suction in compressor, if needed.			☐	☐
	Suggested ECMs:				
	• Load may be less than design. Consider replacing oversized equipment with chiller and water cooled condenser system.			☐	☐
	WATER HEATING SYSTEM				
W-1.	Storage tanks, piping and water heaters are used inefficiently.	☐	☐		
	Suggested O & Ms:				
	• Replace damaged or missing insulation.			☐	☐
	• Reduce hot water temperature to 105°-115°F where allowed by code.			☐	☐
	• Turn off hot water circulating pump during non-occupied hours.			☐	☐
	Suggested ECMs:				
	• Install insulation on all hot water lines and storage tanks.			☐	☐
	• Install a small domestic hot water heater to maintain desired temperature in water storage tank. This could eliminate the need for operating one of the large space heating boilers during summer months.			☐	☐
	• Install de-centralized water heating.			☐	☐
W-2.	Drips or leaks are evident in hot water systems.	☐	☐		
	Suggested O & Ms:				
	• Repair all leaks including those of the faucets and pumps.			☐	☐

		EXISTS		RECOM	
		YES	NO	YES	NO
W-3.	Electric water heater has no time restrictions on heating cycle.	☐	☐		
	Suggested O & Ms:				
*	• Use "vacation cycle" on water heater when not needed during extended periods. NOTE: Complete deactivation could cause leaks.			☐	☐
	• Schedule setbacks (either manually on with existing time clock). Consider schedule's impact on electrical demand.			☐	☐
	Suggested ECMs:				
	• Limit the duty cycle with a time clock or other control devices to avoid adding the water heating load to the building during peak electrical demand periods. (Additional hot water storage capacity may be required.)			☐	☐
W-4.	Water conservation devices are not installed.	☐	☐		
	Suggested O & Ms:				
	• Insert flow restrictors in water faucets and showers.			☐	☐
	Suggested ECMs:				
	• Install mixing valves.			☐	☐
	• Replace standard faucets with self-closing, flow restrictor types. (Highly mineralized water or water containing sediment can cause blockages.)			☐	☐
	• Install a solar water heater to assist in meeting building hot water demand. This can reduce consumption of conventional non-renewable energy fuels in facilities that require large quantities of hot water.			☐	☐
	SPECIAL SYSTEMS				
S-1.	Cooking equipment is not used effectively.	☐	☐		
	Suggested O & Ms:				
	• Cook with lids in place on pots and kettles.			☐	☐
	• Shut down exhaust hood fans when not required.			☐	☐
	• Use microwave ovens.			☐	☐
	• Preheat only until the needed temperature is reached. While this varies with each type of equipment, preheat times average 5 to 15 minutes. If using more than one oven, stagger preheat times.			☐	☐
	• Set thermostats at the lowest temperature that will still achieve desired results.			☐	☐
	• Load the entire oven at once and as quickly as possible to reduce heat loss.			☐	☐
	• Use a second oven only when baking schedules overlap unavoidably.			☐	☐
	Suggested ECMs:				
	• Consider using a heat recovery system.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
S-2.	**Some kitchen exhaust hoods are not used efficiently.**	☐	☐		
	Suggested ECMs:				
	• Use Exhaust hoods only while cooking and when required by code.			☐	☐
*	• If exhaust hood is oversized, adjust it so no more air than necessary is exhausted. This can be done easily by blocking off a portion of the hood, lowering the hood, reducing fan speed, or using a combination of these techniques in compliance with applicable health regulations.			☐	☐
	• Check damper in exhaust hood to ensure that damper closes tightly when exhaust is shut off.			☐	☐
	• Clean or replace grease traps or filters regularly. Grease accumulated on collectors reduces the amount of air being exhausted and is a fire hazard.			☐	☐
*	• Check exhaust fan drives regularly; replace frayed or otherwise damaged drive belts; check drive belt tension.			☐	☐
	Suggested ECMs:				
	• Add control dampers or gravity dampers to keep the air path in the exhaust duct closed when the fan is off.			☐	☐
	• Install control switches that shut off each exhaust fan independently.			☐	☐
	• Modify duct systems and hoods to introduce unheated outdoor or return air directly to the exhaust hood.			☐	☐
	• Replace hoods with new low volume, high velocity hoods that require less makeup air.			☐	☐
	• Replace outside air dampers with the low leakage type.			☐	☐
	• Reduce or eliminate the need for using outdoor air for odor control by installing chemical or activated charcoal absorbing devices.			☐	☐
S-3.	**Refrigeration equipment is not loaded and maintained as recommended.**	☐	☐		
	Suggested O & Ms:				
	• Do not exceed manufacturer's load specifications. An overloaded or underloaded display case will decrease produce quality and increase energy use by as much as 10 to 20 percent.			☐	☐
	• Obtain and follow manufacturer's cleaning recommendations and maintenance schedules. Dirty fixtures and condensers increase compressor operating times and condensing temperatures and decrease cooling capacity.			☐	☐
	• Check all door seals and gaskets for cracks or other damage. A dollar bill inserted between the gasket and door frame should resist withdrawal when the door is closed.			☐	☐
	• Check the operation of fan motors in all fixtures, especially multi-shelf equipment where broken motors can easily go unnoticed.			☐	☐
*	• Check the operation of all expansion valves. They should fully feed the evaporator. Check temperatures, bulb location, and heat pressures.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
S-4.	**Refrigeration equipment is not being operated as efficiently as possible.**	☐	☐		
	Suggested O & Ms:				
*	• Turn off anti-sweat heaters on glass door assembly perimeters, and open display cases when temperature humidity levels are low (less than 35 percent relative humidity).			☐	☐
	• Use the night covers if recommended by the manufacturer. They can reduce compressor running time, product temperatures, and energy used.			☐	☐
*	• If you have a timed defrost system, set the defrost cycle so the freezer will defrost when electrical demand is low and so that different units do not turn on simultaneously.			☐	☐
	• Units should be defrosted as often as necessary to keep the evaporator free of frost.			☐	☐
*	• Adjust air duct diffusers to give the most efficient air flow and balanced air distribution. Check especially that air is not blowing into refrigerator cases. For complex systems, the adjustment should be made by the professional service representative.			☐	☐
	• Thaw frozen food in refrigerator. Food will thaw easily and help reduce power demand for refrigerator.			☐	☐
	Suggested ECMs:				
	• The decision whether to use glass door or open multideck cases is not simple. Before buying open, multideck frozen food cases, consider the entire store plan and the volume of sales expected. The relative amount of power use by glass door versus open multideck cases depends on sales volume. For high-volume use, multideck cases draw less energy than glass door cases. For medium-volume, however, the power required for glass door cases can be 17 percent less than open multideck cases; for infrequent use, as much as 25 percent less.			☐	☐
	• Install separate wiring circuits for anti-sweat heaters, which are high energy users, to allow them to be turned off when humidity is low or to be regulated by a humidistat or other modulating controllers.			☐	☐
	• Where possible eliminate electric condensate evaporators, such as those found in self-contained cases. One energy-efficient alternative is a small condensate pump and a floor drain.			☐	☐
	• Provide night covers for open cases. The energy saved will vary with each type of cabinet. Be certain to contact the manufacturers first because night covers can damage some types of equipment.			☐	☐
S-5.	**In-house laundry equipment is not used effectively.**	☐	☐		
	Suggested O & Ms:				
	• Develop concise operating procedures for each piece of equipment.			☐	☐
	• Iron only items that require it.			☐	☐
	• Wash and dry full loads only.			☐	☐
	• Consider rescheduling laundry work hours to avoid peak electric load periods.			☐	☐
	• Consider cold water detergents.			☐	☐
	Suggested ECMs:				
	• Consider using heat recovery.			☐	☐

		EXISTS YES	EXISTS NO	RECOM YES	RECOM NO
S-6.	**Special diagnostic and treatment equipment is not used effectively.**	☐	☐		
	Suggested O & Ms:				
	• Periodic update on operation of equipment by equipment manufacturer's representative.			☐	☐
	• Reduce start-up and shut-down times.			☐	☐
	• Consider scheduling this equipment during electrical off-peak periods.			☐	☐
	Suggested ECMs:				
	• Consider using heat recovery.			☐	☐
S-7.	**In-house computer system is used continually during daytime.**	☐	☐		
	Suggested O & Ms:				
	• Check cooling air temperatures for computer to confirm correct temperatures.			☐	☐
	• Minimize air leakage in and out of computer area.			☐	☐
	Suggested ECMs:				
	• Consider using heat recovery.			☐	☐
S-8.	**Swimming pool water temperature too high (above 85°F). Circulating pumps run continually.**	☐	☐		
	Suggested O & Ms:				
	• Reduce water temperatures to 80°-84°F if users do not object.			☐	☐
*	• Indoor pool: turn off heater and circulating pumps until an hour before use.			☐	☐
	Suggested ECMs:				
	• Outside pool: Cover when not in use.			☐	☐
	• Use pool as part of heat recovery scheme and solar system.			☐	☐
S-9.	**Elevator motor generator runs continually.**	☐	☐		
	Suggested O & Ms:				
	• Reduce the number of elevators in service during hours when majority of persons are not leaving or entering the building.			☐	☐
	• Turn off the motor-generator set in the elevator machine room when not in use: nights, weekends, holidays, and slack periods during the day.			☐	☐
*	• Reduce speed of elevator.			☐	☐
	Suggested ECMs:				
	• Consider changing from motor-generator to a more efficient solid state controller.			☐	☐

STEP 3: AUDITOR INFORMATION FORM

1. I conducted the energy audit as a:
   - ☐ Staff member or representative of an eligible institution
   - ☐ Licensed engineer or architect
   - ☐ Utility staff member
   - ☐ Other (specify)

2. My financial interests in connection with this energy audit are:
   - ☐ No outside interest
   - ☐ Own or am employed by one of the following:
   - ☐ a consulting firm
   - ☐ an equipment manufacturer or supplier
   - ☐ an energy supplier
   - ☐ other (specify) _____

3. Address of auditor: _____

   _____

   Telephone number _____

4. I have completed this energy audit workbook accurately and thoroughly to the best of my knowledge and abilities.

   Signature _____

   Date _____

STEP 4: WORKBOOK MAILING INSTRUCTIONS

1. Have you fully completed the Building Energy Consumption Inventory in STEP 1?
2. Have you fully completed the Energy Audit Checklist in STEP 2?
3. Is the auditor Information Form, STEP 3, completely filled out and signed by a qualified auditor? This is a requirement.
4. Send the original and one copy of the workbook (pages 1-40) along with the application to:

Montana Department of Natural Resources
and Conservation - Energy Division
Attention: ICP Program Manager
1520 East 6th Avenue
Helena, MT 59620

COMMON OPERATION AND MAINTENANCE (O & M) ITEMS

BUILDING ENVELOPE:

- •Install or replace window/door caulking or weatherstripping
- •Repair or replace broken windows/doors
- •Install plastic film storm windows
- •Repair roof leaks and replace insulation

HEATING OR COOLING EQUIPMENT:

- •Adjust supply or heat transfer medium temperatures
- •Reduce or eliminate heating or cooling at night or when a building or complex is unoccupied.
- •Maintain/tune equipment
- •Remove scale and cleaning tube

HVAC (heating, ventilating, and air conditioning) DISTRIBUTION SYSTEMS:

- •Reduce outside air intake
- •Shut down ventilation systems in unoccupied areas and in all areas at unoccupied times
- •Install pipe or duct insulation

CONTROL SYSTEMS:

- •Lower indoor temperatures in winter and raise in summer
- •Install locking thermostats
- •Adjust controls
- •Raise settings for chilled water temperatures
- •Reduce operating times for circulating pumps

WATER HEATING SYSTEMS:

- •Reduce hot water temperature
- •Install tank insulation
- •Repair leaks
- •Install flow restrictors

LIGHTING SYSTEMS:

- •Reduce illumination levels: Remove or disconnect lamps/ballasts
- •Maximize use of daylight
- •Replace burned out lamps/ballasts with higher efficiency lamps/ballasts
- •Reschedule night staff (janitors) to reduce time that lights are operated

UTILITY PLANT AND DISTRIBUTION

- •Clean equipment
- •Adjust air/fuel ration
- •Monitor combustion
- •Adjust fan, motor, or belt drive systems
- •Maintain steam traps
- •Repair distribution pipe insulation

COMMON ENERGY CONSERVATION MEASURES (ECMs)

BUILDING ENVELOPE:

- •Insulate roof or attic
- •Close skylight
- •Insulate wall
- •Replace/modify window
- •Reduce window
- •Insulate overhead door
- •Construct vestibule
- •Replace door
- •Weatherstrip window/door
- •Seal passive ventilator

HEATING EQUIPMENT:

- •Install high efficiency boiler
- •Reduce steam pressure
- •Insulate boiler
- •Install heating water reset
- •Install high efficiency/modulating burner
- •Install oxygen trim control
- •Install flue damper
- •Install high efficiency furnace
- •Install heat pump, air or water source
- •Install radiant heating system
- •Install thermostatic radiator valves
- •Replace steam trap
- •Modify unit ventilator
- •Install solar space heat, active or passive

COOLING EQUIPMENT

- •Install modulating load control
- •Install multiple compressor sequencing
- •Install economizer cycle
- •Install evaporative/desiccant cooling

Appendix A

The following table breaks down the average energy use for schools and universities in cold climate areas of the United States. The values were obtained from an EPRI report entitled, "A review of Commercial Sector Energy Use Indexes(1988)." These values can be used as a guideline to see how a building compares to national averages. Please remember that these values are averages and actual values could differ greatly depending on specific building technologies, level of service provided, and building characteristics.

Energy Use Estimates For a Cold Climate

Energy Type	Schools	Colleges
Electricity	kBtu/ft2	kBtu/ft2
Heat	1.3	1.4
Cool	4.1	8.1
Ventilation	2.0	7.3
Water	1.0	0.7
Cooking	1.3	0.8
Refrigeration	1.3	1.8
Lighting	12.5	17.3
Misc	2.5	5.8
	25.9	43.2
Natural Gas		
Heat	30.6	28.9
Cool	1.8	0.6
Water	8.5	10.8
Cooking	3.9	3.8
Misc	3.0	5.0
	47.7	49.0
Total	73.6	92.2

Appendix B

Energy Use Index

The energy use index(EUI) can be defined as the total energy use divided by the gross square feet of the building. Since heating is a major energy use of buildings in Montana, the EUI is further refined by including the Heating Degree Days (HDD). A HDD is defined during the heating season as the difference between 65 F and the average temperature for that day. By comparing the accumulated HDD's from year to year, the severity of the winter can be quantified. The modified EUI is found by dividing the Btu/ft2 by the HDD. For example if a building has roughly 8000 HDD for the year then:

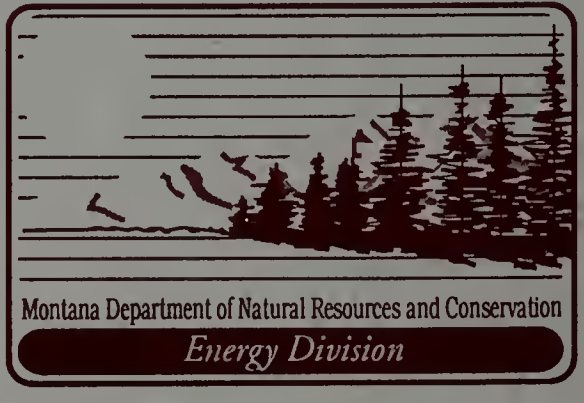
$$EUI = \frac{75{,}000 \text{ Btu/ft2}}{8{,}000 \text{ HDD}} = 9.4$$

By calculating the EUI, a building operator can accurately compare the energy use from year to year. Also, after an energy retrofit project is completed, your EUI should drop. Here are some examples of EUI's from past energy retrofit projects completed through the ICP program.

Building	MBtu(initial)	MBtu(final)	Area(ft2)	HDD	EUI(initial)	EUI(final)
			9 Month Facility			
High School	4063.7	3393.0	32386	6578	19.0	15.9
H.S. Gym	2410.4	1822.0	19500	7954	15.5	11.7
Elem. Sch.	5934.7	3367.7	36985	7542	21.3	12.0
			12 Month Facility			
Hospital	7513.6	6010.6	39049	6693	28.7	23.0
College Classroom	10919	3140.0	53223	8853	16.2	7.0
Career Ctr.	9760.6	9305.9	11048	6560	13.5	12.8

ADDITIONAL ENERGY AUDITOR COMMENTS:

ADDITIONAL ENERGY AUDITOR COMMENTS:



Montana Department of Natural Resources and Conservation

Energy Division